FORETELL™: Providing Integrated Weather Information Services Across the Upper Midwest

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Weather has an enormous effect on travel and road conditions. Drifting snow, ice, fog, and gusty winds are some of the weather events that contribute to the deaths of more than 1150 U.S. and Canadian highway users every winter. Adverse conditions cut surface friction, impact highway capacities and reduce accessibility, damaging industry and rural economies alike. To help address these difficulties, various agencies within the U.S. and Canada are currently working together in the FORETELL™ project to develop an integrated strategy for providing detailed, up-to-the-minute weather information dissemination services, bringing to fruition many of the products of meteorological and transportation research initiatives. This paper explores the possibilities for innovative approaches to providing road and weather condition information to diverse users, and suggests ways to broaden the traditional views of information provision through wide-ranging public / private partnerships. Details are provided of the FORETELL™ initiative, currently funded through FHWA research and development, which involves the Departments of Transportation of Iowa, Missouri, and Wisconsin. Many other public and private sector agencies are also participating. Key words: road conditions, weather, maintenance, safety, travel information service.

INTRODUCTION

Weather has an enormous effect on travel and road conditions. Drifting snow, ice, fog, and gusty winds are some of the weather events that—at least in part—kill more than 1150 U.S. and Canadian highway users every winter. Adverse conditions cut surface friction, impact highway capacities and reduce accessibility, hurting industry and rural economies alike. Over $2 billion is spent on snow and ice control each year in North America (*1*). Despite this, estimates indicate:

- between 25 and 35 percent of inter-urban incidents occur during adverse weather conditions;
- accidents increase during adverse weather by factors of between two and five;
- U.S. injury accidents alone exceed 65,000 due to adverse road conditions.

Adverse conditions increase travel times, boost drivers' anxiety and stress levels, and slash safety margins. The 1994 Minnesota Guidestar Rural Scoping Study (*2*) found that travelers' most-desired information would detail road and weather conditions. Other weather information needs analyses, such as the Strategic Highway Research Program (SHRP) Storm Monitoring and Communications Project, as well as studies conducted by intelligent transportation systems (ITS) groups such as ENTERPRISE, and road-weather programs like Aurora, show that:

- The most important need is to pull together all of the existing weather and road condition data sources. An effective road-weather information system should not be limited to one or a few data sources, but should integrate information from all available locations including the National Weather Service (NWS), Environment Canada (EC) and private "value-added" weather services, as well as Road Weather Information System (RWIS) field stations.
- As weather honors neither political boundaries nor institutional divisions, agencies and firms must share information to improve their weather tracking and monitoring capabilities. A key concept is to gain synergy through seamless data exchange and joint development efforts.
- Road-weather information must be timely and accurate. Detailed, location-specific forecasts and nowcasts are essential. The numerous advances in meteorology, computing power and telecommunications have created a situation in which forecasters have more to offer transportation operators and users than ever before.
- Users require multiple means of information access, including radio, TV, conventional and cellular phone, pager, and Internet. Information must be available on-demand and should also be available in tailored packages "pushed" to key users when threshold conditions are exceeded.
- Users need flexible information presentation formats. The information is too complex to load all the data on everyone. Effective, proven decision support systems are vital for user buy-in.
- An open system architecture is essential. Due to the complexity of advanced weather systems and ITS, and the number of fast-evolving information systems that should be linked together, it is imperative that standardized communications protocols, such as the NTCIP "Environmental Sensor Stations (ESS)" initiative, be utilized from the start.

THE FORETELL™ INITIATIVE

FORETELL™'s state, research agency and private sector partners come from diverse ITS and meteorological backgrounds, and yet

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share a common resolve to see detailed road and weather information become an everyday commercial reality. Iowa DOT is the lead public sector agency. Iowa has made major investments in RWIS, has equipped 39 rest areas with real-time weather information systems, has led the ITS ENTERPRISE Program, and is active in the road-weather Aurora pooled fund study. Castle Rock Services (CRS) is the private sector lead. CRS already runs two ITS Service Centers in public-private partnership with Virginia DOT, suburban and rural centers whose immediate success has already done much to validate the Service Center concept.

FORETELL™'s public sector partners have already shown their trust in intelligent weather systems by investing significant public funds into the sophisticated infrastructure behind this advanced weather systems/ITS approach. The initial FORETELL™ deployment will cover five states in the Mississippi Valley region, plus western Ontario. This heartland includes plains, forests, lakes and rolling terrain. FORETELL™ touches on major metropolitan areas including Chicago, Milwaukee, Minneapolis/St. Paul, Kansas City and St. Louis. This large and diverse geographic setting allows users' needs for and responses to the integrated surface transportation weather information system to be explored.

By initially investing $4,450,000 (including $1.3 million in FHWA funding) in this first, regional phase of the FORETELL™ road and weather information system partnership, the program aims to improve safety and ease winter travel, leading to more cost effective roadway maintenance, operations and environmental benefits. Additionally, FORETELL™ will serve a whole range of public, quasi-public, private and traveler client groups, eventually it is hoped generating self-sustaining cash flows and subsequent returns on investments for long-term private and public partners.

In addition to this direct funding, through its partnership with the National Oceanic and Atmospheric Administration (NOAA), FORETELL™ is building on the committed $4 billion National Weather Service modernization and on the $370M annual Federal meteorological research budget. For example, FORETELL™ partner Forecast Systems Laboratory (FSL)'s Federal funding alone exceeds $20M/year, a commitment spent entirely on intelligent weather systems development. FSL's work on precise forecasting and advanced decision support systems, executed over more than 10 years, will reach one of its full applications through FORETELL™.

Technical Approach

The basis of FORETELL™'s system design is the integration of Intelligent Weather Systems (IWS) and Intelligent Transportation Systems (ITS) technologies. FORETELL™ builds upon the National Weather Service modernization and restructuring (MAR) and on equivalent investments being made by Environment Canada. NWS atmospheric models are being linked to pavement conditions based on proven Swedish and UK approaches, providing a starting point for further, innovative developments in road condition forecasting. These data fusion, road condition prediction and multimedia information dissemination activities are focused in new ITS Service Centers, as the core of a much broader "basket" of commercially-viable ITS services.

In more detail, the FORETELL™ design concept brings together all available weather data sources, including satellites, radars, wind profilers, airborne platforms (i.e. commercial jets), and surface sites including those of NWS, DOD, aviation and conventional RWIS stations in the FORETELL™ states. To these FORETELL™ is adding road-vehicle mounted mobile data platforms. Rigorous quality control algorithms will be applied to automatically filter out suspect sensor data and support effective maintenance/recalibration programs. State-of-the-art mesoscale models will support fine resolution (10 km grid in the U.S.; 12 km grid in Canada) nowcasts and forecasts. NOAA's proven decision support systems will allow complex data outputs to be understood and acted upon by highway maintenance staff, commercial vehicle operations (CVO) dispatchers and individual travelers.

European practice already links site-specific pavement condition forecasts based on energy balance models to mesoscale atmospheric model outputs. FORETELL™ is refining these approaches and applying them at much higher levels of detail, initially for 1 km road segments and later down to 1-5 meter microscale resolution and hourly intervals. Mobile ESS (Environmental Sensor Station) data collection platforms gathering real-time thermal profiles and air temperature/dewpoint/windspeed data will give input to these microscale models. In later deployments, a fish-eye lens digital camera with a global positioning system (GPS) and on-board processing will provide the database for innovative solar gain pavement temperature projections. Crosswinds measurement from the mobile platforms will address snow drifting, linking local eddies to the broader pattern of mesoscale surface winds. Eventually a visibility nowcaster will process air and surface temperatures, dew points and related factors.

ITS Service Centers are providing the focus for data fusion, road condition forecasting and information dissemination activities. Planned dissemination media include commercial radio and TV, conventional and cellular telephone, pager, and Internet, as well as existing and upcoming ITS traveler information systems such as highway advisory radio, dynamic message signs and (when commercially viable) AM phase modulation and/or FM subcarrier systems. Data packages will be tailored to specific market segment requirements, with basic safety information provided free at the point of use. Value-added services will include those funded by advertising and sponsorship, as well as subscription services. Both on-demand and information "push" technologies will be supported.

Current Systems in Place

Because FORETELL™ builds upon the entire set of weather service, aviation, defense, agriculture and emergency management hydrometeorological data collection systems, as well as on conventional RWIS, it enjoys the benefits of a frankly awesome multibillion dollar array of currently deployed systems. More than 95% of FORETELL™'s data comes initially from sources other than RWIS. Recent advances in radar, automated weather observing systems, super speed computers, satellite, sophisticated information processing and communications systems provide the foundations of FORETELL™'s warnings and forecasts. Systems being harnessed for FORETELL™ include:

- the Next Generation Weather Radar (NEXRAD or WSR-88D);
- the NWS Automated Surface Observation System (ASOS);
- the National Centers for Environmental Prediction (NCEP);
- weather satellites, developed and operated by NOAA's National Environmental Satellite, Data and Information Service (NESDIS);
- the NWS Advanced Weather Interactive Processing System (AWIPS)
- numerous advanced communications networks, including the

NWS one-way, point-to-multipoint satellite broadcast service called NOAAPORT;
- the 118 NWS Weather Forecast Offices (WFOs); and
- the 170 RWIS sites currently operational in FORETELL™'s initial area.

The FORETELL™ Project Structure

In Module 1, the National Center for Environmental Prediction (NCEP), National Weather Service Local Forecast Offices, NOAA's Forecast Systems Laboratory (FSL), and the Canadian Environment Service (AES) are working to provide sensor data and the output of mesoscale atmospheric models for the FORETELL™ states.

In Canada this work is being undertaken by AES in the Canadian Meteorological Centre (CMC) in Dorval, Quebec. Environment Canada is cooperating closely with NOAA agencies in FORETELL™'s Module 1, pursuing similar approaches in leading edge meso-scale numerical modeling at the Canadian Meteorological Centre to provide high resolution model outputs north of the border. Selected EC Ontario Regional Centres will integrate their data collection, forecasting and dissemination activities with those developed in National Weather Service LFOs and in ITS Service Centers in the United States.

In Module 2, Castle Rock Services (CRS) is working with State DOTs to establish Rural ITS Service Centers in the Mississippi Valley. The Service Centers will serve as data fusion points, and to operate the road condition forecast models. In Canada, EC will undertake similar activities in Dorval and its regional centers in Ontario, linking up with the Ministry of Transportation of Ontario (MTO) and its private sector winter maintenance contractors. Finally, FORETELL™ members are also working on several innovative technology insertions.

In Module 3, Castle Rock Services will further develop the service centers deployed in Module 2 to eventually support a "basket" of ITS User Services in conformance with the National ITS Architecture, ultimately providing a broad and diverse funding base with maximum self-sustaining potential. Private sector investments are funding the set up and operation of equipment and systems to perform information dissemination to the traveling public. State and Federal funding will support information dissemination to State DOTs and to other public and quasi-public agencies. Acting as public-private partnerships, with joint staffing and shared facilities, the Service Centers will serve clients drawn from the diverse "core" groups of users.

In Module 4, FORETELL™ is building on 30 American Mobile Satellite Company (AMSC) GPS/satellite communications on-board computer units already developed within Iowa DOT's CVO operational test (the on-board automated mileage & stateline crossing system for apportioning commercial vehicle fuel taxes and mileage or AMASCOT). IA/DOT is working with AMSC to add pavement temperature sensors (as currently used in thermal mapping), air temperature sensors, relative humidity and wind speed sensors. The Iowa/Minnesota/Michigan maintenance concept vehicle will thereby be enhanced to serve as a mobile platform to collect and transmit back road surface and atmospheric weather information. Other Rockwell units are being deployed on regular snowplows, state patrol cruisers, rural buses, etc., to fully evaluate the mobile platform concept across the FORETELL™ states.

FORETELL™ is integrating the mobile weather monitoring equipment with AMASCOT GPS/satellite communications on-board computers. Resulting measured air and pavement temperatures, wind speeds and directions will be logged on board maintenance vehicles but also radioed back to the ITS Service Centers in real time. Wind speed will provide a direct input into snow drift forecasting. Air temperatures and winds will be made available to the NWS, as ACARS aircraft observations are already provided today. Pavement temperature data will be used at the Rural ITS Service Centers to enhance site-specific pavement condition forecasts.

CONCLUSIONS

In conclusion, FORETELL™'s benefits are expected to include:
- an ability to "grow" multi-regional and national/North American systems, based on initial lessons learned regarding the impacts of region-wide weather nowcasts and forecasts on the behavior, productivity and safety of travelers and maintenance personnel;
- public-public and public-private partnerships that result in improved linkages to, and coordination between, FORETELL™ members, affiliates, and their existing and planned RWIS and other related ITS deployments;
- an integrated road and weather system that crosses state and national borders, allowing the comparison of United States and Canadian weather forecasting models, and the seamless distribution of tailored weather and road information to FORETELL™ users;
- the flexibility to evolve and further innovate as the system grows across the North American Continent, based upon fast-developing technologies, changing customer applications and increased expectations; and
- the promise of cutting costs and substantially benefiting the environment by increasing the levels of forecast detail, eventually to hourly and micro (1-5 meter) resolution, thereby enabling maintenance concept vehicles to greatly reduce the amount of chemical required to anti-ice and de-ice roadways.

Finally, FORETELL™ showcases how federal agencies can effectively team with the private sector to meet a common goal: to improve and modernize weather information forecasting and delivery systems. In the case of the Department of Commerce, this illustrates the vital role of the National Weather Service in partnering with key players across a multi-billion dollar user market segment—transportation. In the case of U.S. DOT, the program will lead to an integrated, seamless system that meets highway operators' and users' needs for clear and accurate road and weather information.

REFERENCES

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